Space Information Laboratories

# Lithium Ion *Intelli-Pack* Battery

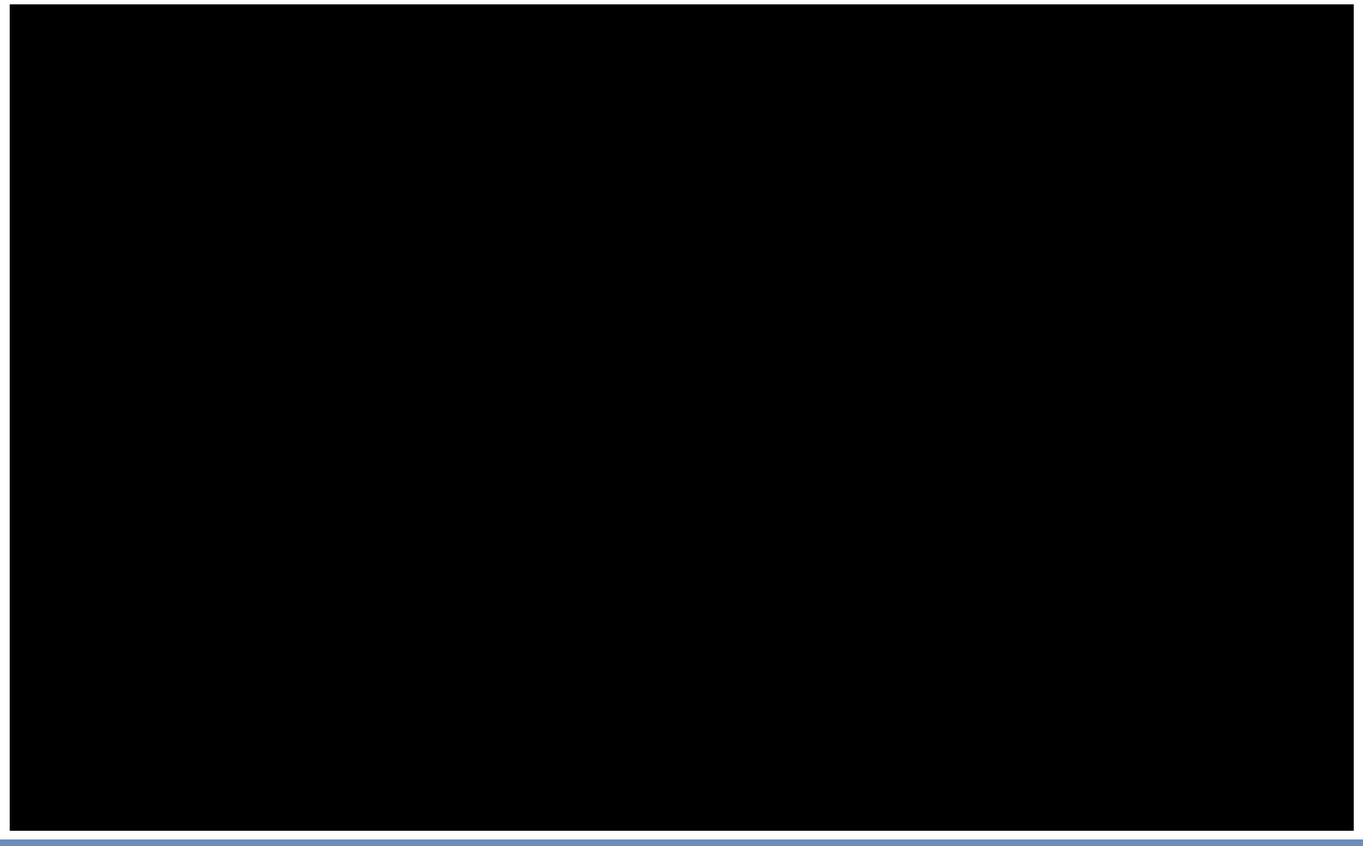
## *For Launch Vehicles, Missiles, Satellites, ISS, Balloons, Aircraft and UAVs*

## *An Intelligent Power System Technology*

**NASA MSFC Battery Workshop**
**14-18 November 2011**

# SIL Technology Video

Duration 2 Minutes



# Li-Polymer Battery Technology

## Typical Lithium Ion Polymer 4.2Vdc Cell (.5 to 50 Ah)

- 2.97” L x 2.56” W x .2” H
- 4.2V, 5 Ah, 233.5 Wh/Kg
- Solid Polymer Electrolyte with no electrolyte leakage
- Works in a space vacuum
- Teflon wire soldered directly to tabs – no risky weld joints

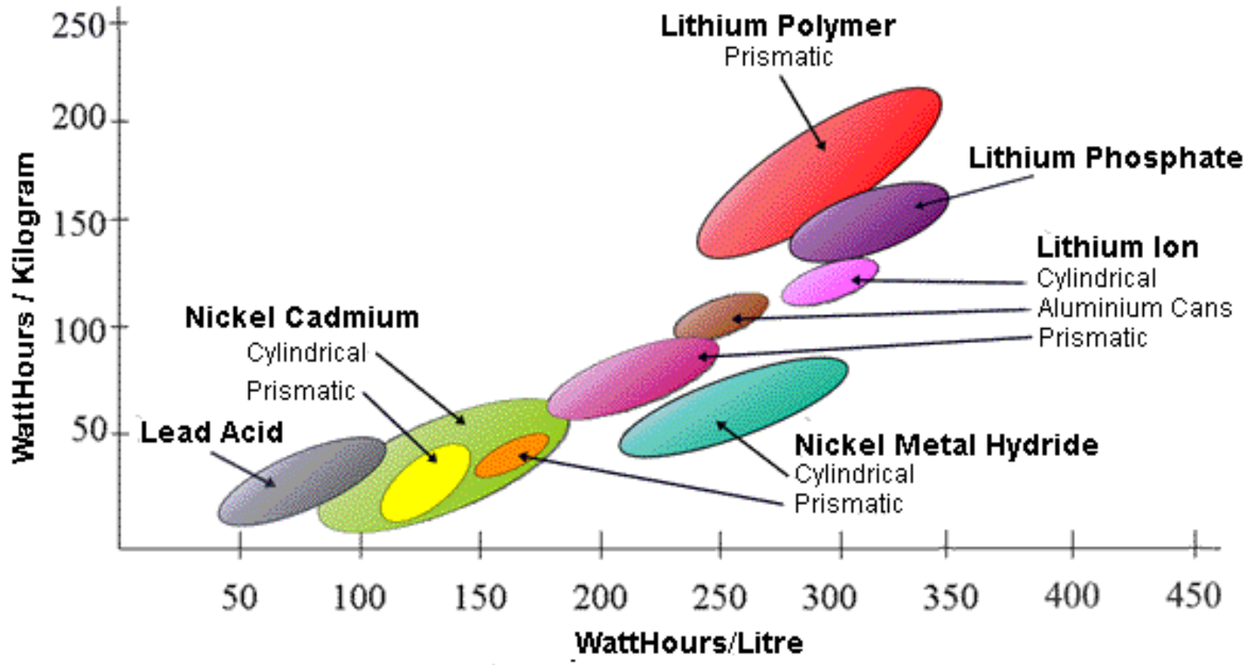
# SIL Cell Battery Testing

- SIL performs Li-Ion Polymer and Li-Ion 18650 cell screening testing prior to assembling the Lithium Intelli-Pack Battery System for LV/Missile, Satellite, ISS and other Aerospace platforms.
  - Cell screening performed per RCC 319-07 Lithium Ion Section 4.26 (capacity, self discharge / long-term storage, load test characterization, and temperature cycling).
  - Testing is performed in a vacuum at C/10 to C/2 discharge rates for satellite applications.
  - Cells are characterized and matched by lot and performance to ensure uniform pack / balancing characteristics

# Li-Polymer Battery Technology Features

- Lithium Polymer cells have ***no liquid or toxic electrolyte***
- Immune to vibration and shock with proper constraints
- Tested in hard space vacuum and flown on CubeSats and AFRL SmallSats without issue
- ***Mechanically adaptable*** to multiple dimensions
- ***High energy density***, 200-250 Wh/Kg
  - *3x the density of Ni-cad Batteries*
  - *6x the density of Lead-Acid Batteries*
  - *2x the density of Silver Zinc Batteries*
  - *~1.5x the density of typical Lithium-Ion cells*
- ***Wide thermal operating range*** of -20C to +70C
- ***Excellent performance under cold temperatures*** as compared to Ni-Cad, Silver Zinc and/or Lithium Ion batteries
- No maintenance or complex lab equipment required for conditioning or safety

# Relative Energy Densities



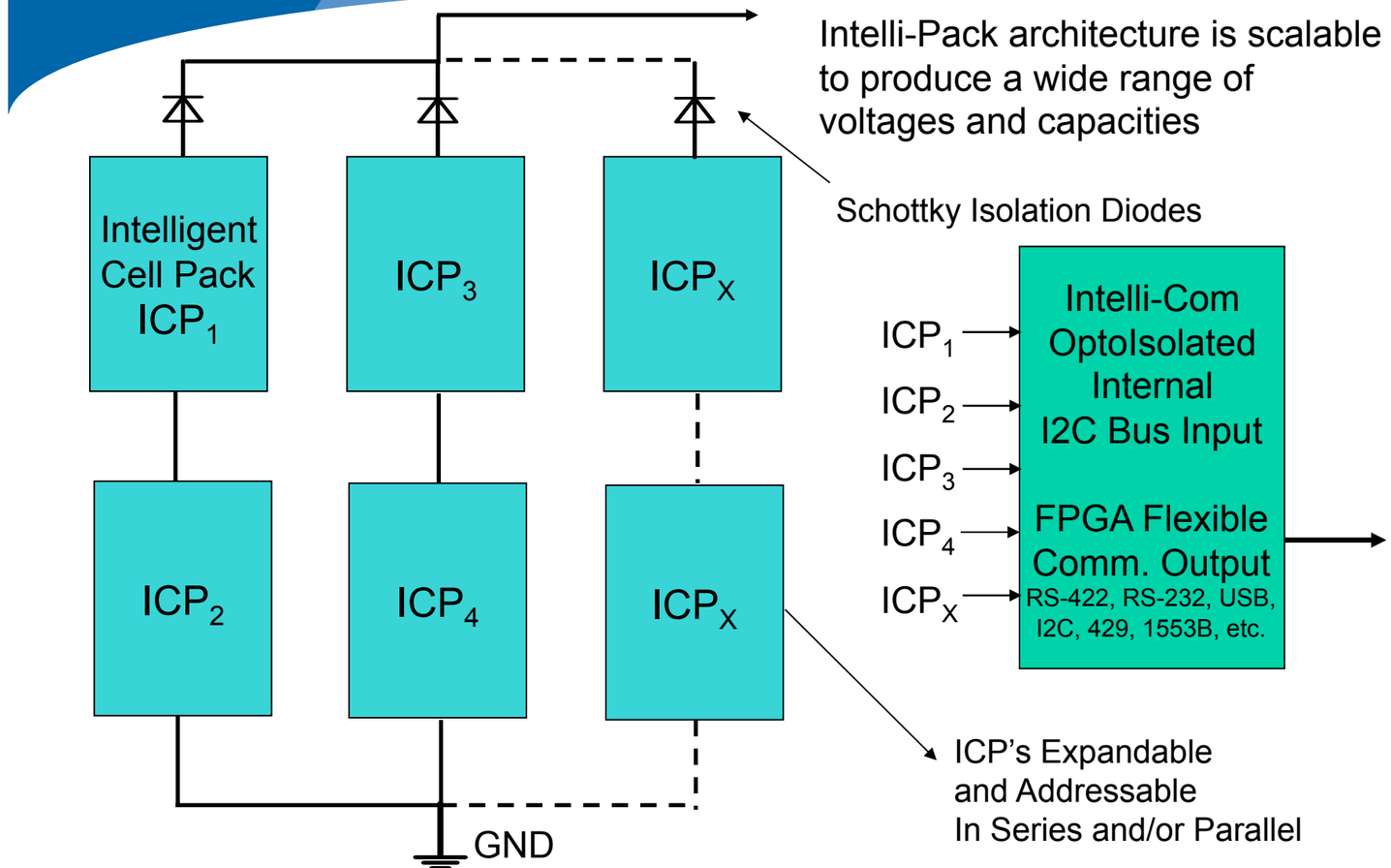
# SIL Aerospace Battery Comparison Chart

| Battery Characteristic | Silver Zinc | Lithium-ion Polymer | Nickel Cadmium | Lithium-ion Iron Phosphate | Lithium Ion Cylinder |
|---|---|---|---|---|---|
| **Cost ( $ / Wh)** | 50 - 75 | 1 | .75 – 1.5 | 1.5 - 2 | 1 – 1.5 |
| **Cell Voltage (V)** | 1.85V - 1.2V | 4.2V – 3V | 1.4V – 1V | 3.7 V – 2.5V | 3.6V – 2.2V |
| **Current Sink Capability** | 3 – 4 C<br>5 - 10C (Pulse) | 2 – 5 C<br>10C (Pulse) | 1 – 2 C | 2 C<br>3-4C (Pulse) | 1C |
| **Energy Density (Wh / Kg)** | 70 – 100 Wh/Kg | 200 – 250<br>Wh/Kg | 30 – 45<br>Wh/Kg | 125-150<br>Wh/Kg | 125-200<br>Wh/Kg |
| **Temperature Range (C)** | +4C - +74C | -20C - +70C | -20C - +50C | -20C - +70C | -20C - +50C |
| **Mechanical Adaptability** | Limited<br>Configurations | Unlimited<br>Configurations | Limited<br>Configurations | Limited<br>Configurations | Limited<br>Configurations |
| **Cycle Life** | 10 to 30 Cycles | >500 cycles to 80%<br>rated capacity | >1000 Cycles to 80%<br>rated capacity | >2000 Cycles<br>to 80% rated capacity | > 500 Cycles to 80%<br>rated capacity |
| **Liquid Electrolyte** | Yes, Subject to<br>Leakage –<br>Potassium<br>Hydroxide | No | Yes, Subject to<br>Leakage –<br>Potassium<br>Hydroxide | Yes, Subject to<br>Leakage –<br>Lithium Salt in<br>Organic Solvent | Yes, Subject to<br>Leakage –<br>EC:DMC:DEC:EMC |
| **Vibration and Shock Tolerance** | Good | Excellent | Good | Good | Good |
| **Optimal Recharge Time** | 16 hours @ C/2 | 2-3 hours @ C/2 | 16 hours @ C/4 | 4-6 hours @ C/4 | 12 hours @ C/3 |
| **Memory Effect** | None | None | Yes | None | None |

# Methodology and Design Approach

- ***Modular, scalable and flexible*** battery design with cell voltage monitoring, individual cell protection (under voltage, over voltage and short circuit) and balancing
- ***Thermal control*** of battery temperature via optional Kapton strip heaters between the cells for operating in temperatures below -20C
- ***Wide variety of external telemetry interfaces*** including RS-232, RS-422, USB, I2C, 1553B, Arinc 429, Spacewire, etc…
- ***Custom GUI Software*** for real time battery system monitoring and test evaluation (Functional Qualification / ATP Testing)
- ***38999 Series III connectors*** for simple integration with existing and future aerospace systems
- ***Ease of Integration*** into customer applications using either SIL or customer provided enclosures and mounting hardware
- ***Total support*** throughout design, integration, and operation from a team committed to excellence

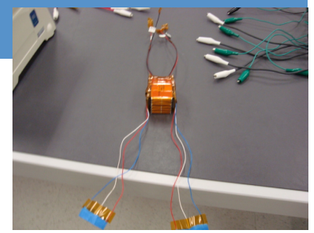
# Scalable, Modular and Intelligent Power System (SMIPS)



# Cell Protection, Balancing and Monitoring

- Over-voltage Protection 4.15 to 4.4 +/- 0.050V
- Under-voltage Protection 2.0 to 2.9 +/- 0.10V
- Battery Discharge Protection
    - Configurable Over-Current Protection
- Cell Balancing
    - Battery management system balances cells during charging to ensure individual cells in series are at the same state of charge (SOC)
- Monitoring (RS-232, RS-422, USB, I2C, Arinc 429, 1553B Ports)
    - The battery management system monitors overall battery state of charge, individual cell voltages, battery temperature, and charge/discharge current

# 12.6Vdc CubeSat Intelli-Pack Battery System (3AH)



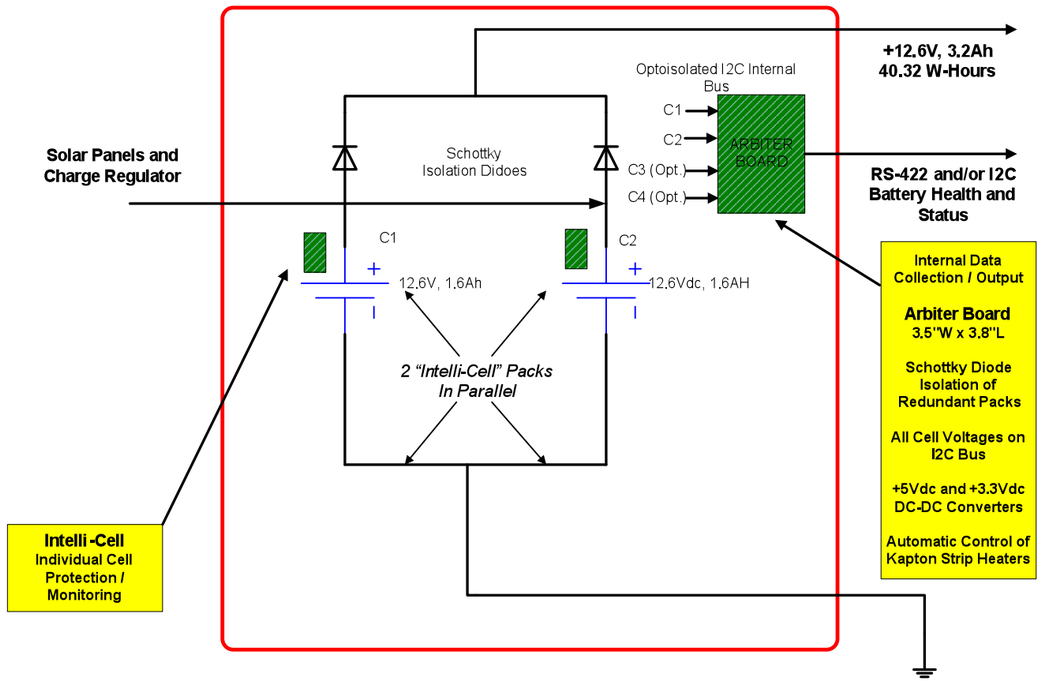
## SIL Intelli-Pack™ and Intelli-Cell™ Advanced Lithium Polymer Battery System

*An intelligent solution for today's aerospace applications*

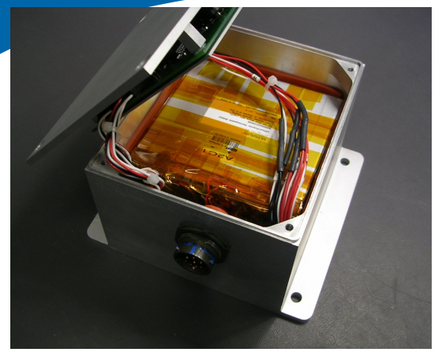
**A 12.6V PnP Nano-Sat Intelli-Pack BATTERY CONFIGURATION**

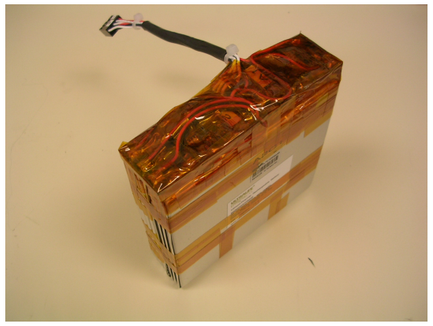
**FEATURES**

- **Overvoltage and Undervoltage Protection**
- **Overdischarge / Short Circuit Protection**
- **Parallel Pack Redundancy**
- **Individual Cell voltage monitoring and recording**
- **Solar Charge Regulator**
- **Kapton Strip Heaters between cells with automatic heater activation at -10C to 0C**
- **Temperature monitoring on each 12.6Vdc Pack**
- **Each 12.6Vdc Li-Polymer Battery (three Li-Polymer Cells, 4.2Vdc, 1.6AH each)**
- **Regulated +5Vdc and +3.3Vdc Military rated DC-DC Converters**
- **RS-422 and/or I2C Interface for transfer of battery information for satellite downlink**
- **Upgradeable and Expandable (Modular and Scalable Design)**
- **Shock, Vibration, Space Qualified (Minuteman III Levels)**



# SIL 33.6Vdc Avionics Intelli-Pack Battery System (6.6AH)

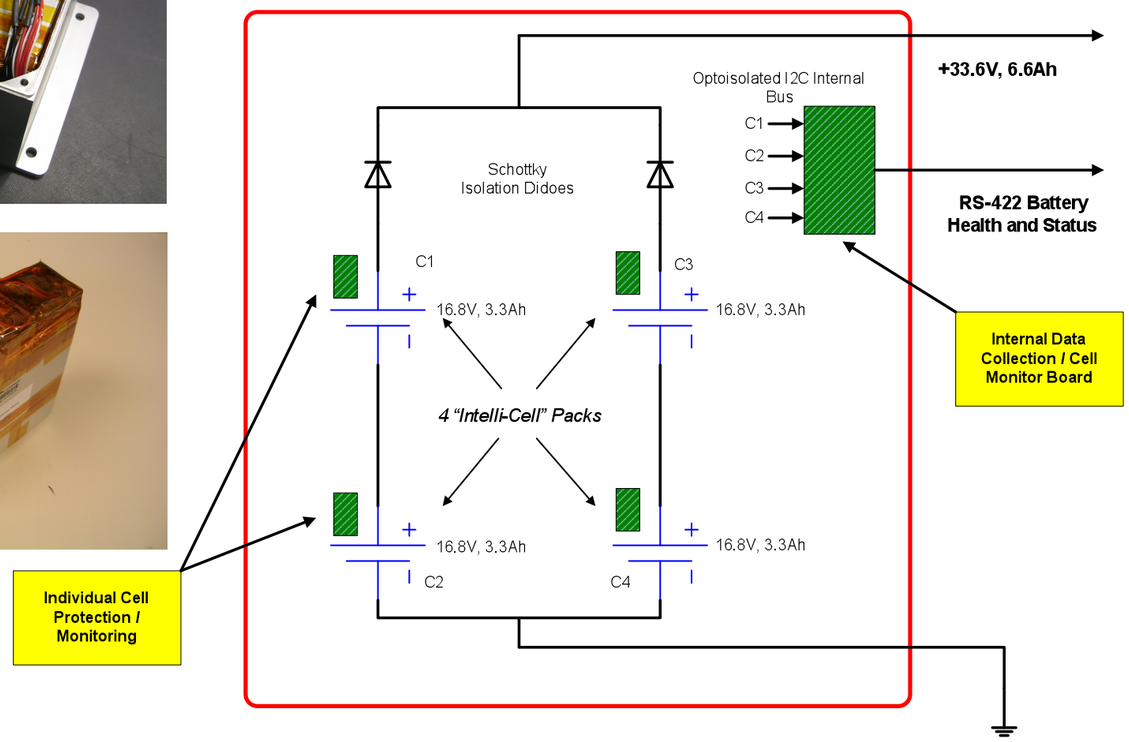




**A 33.6V FLIGHT BATTERY CONFIGURATION**

Weight: 5 lbs

Size: 5.5”L x 4.7”W x 3.5”H

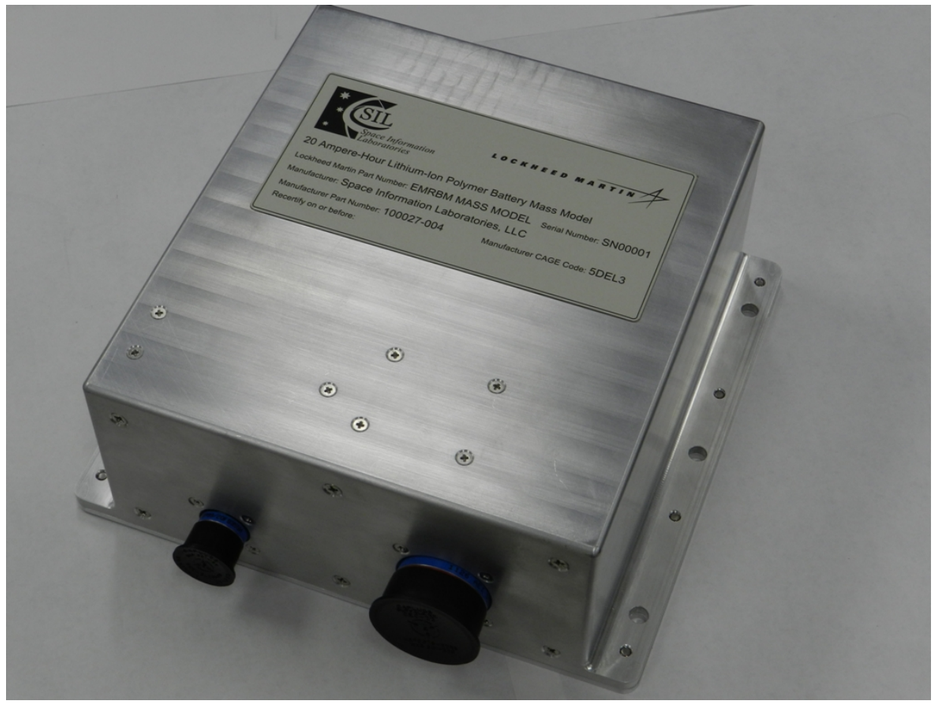


# SIL 33.6Vdc Avionics Intelli-Pack Battery System (20 AH)

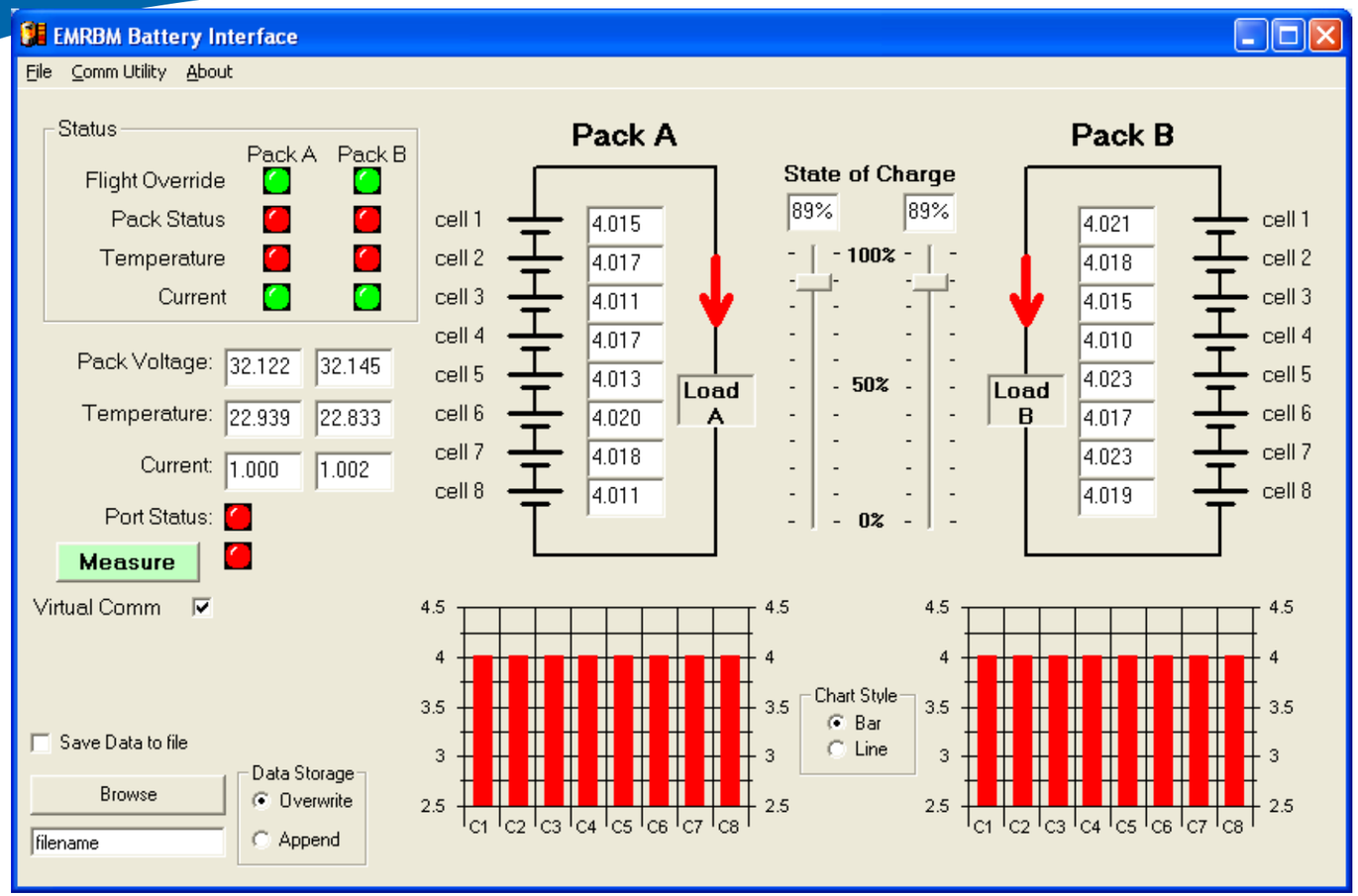
Weight: 13.5 lbs

Size: 9” L x 7.5” W x 3.5” H

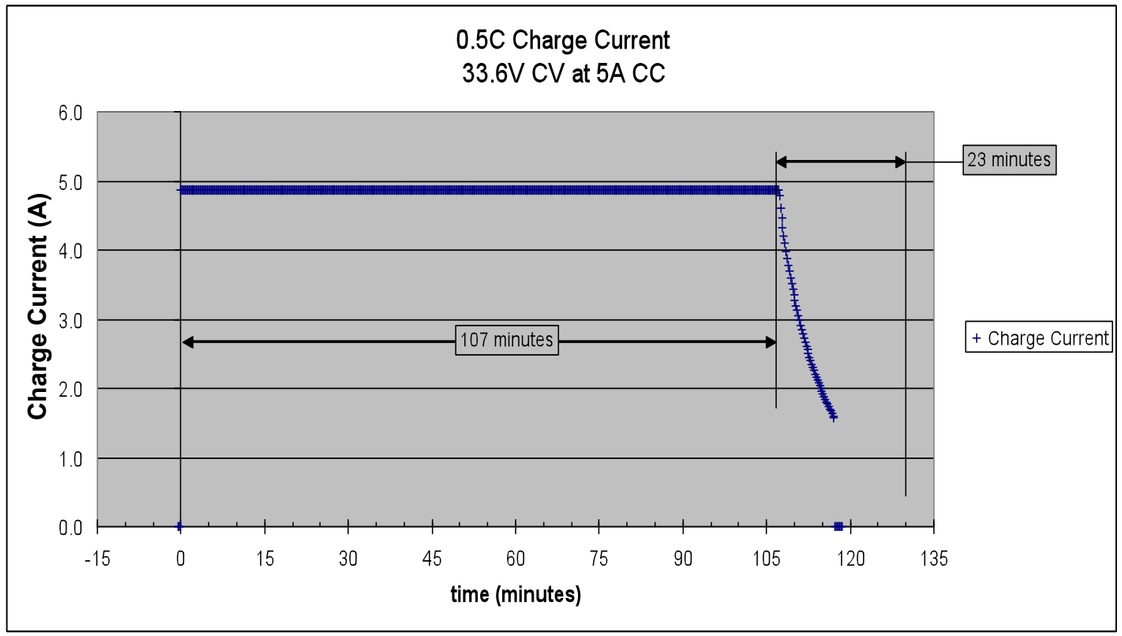
RS-422 and MIL-STD 1553B Data Outputs



# Li-Polymer Intell-Pack Windows GUI

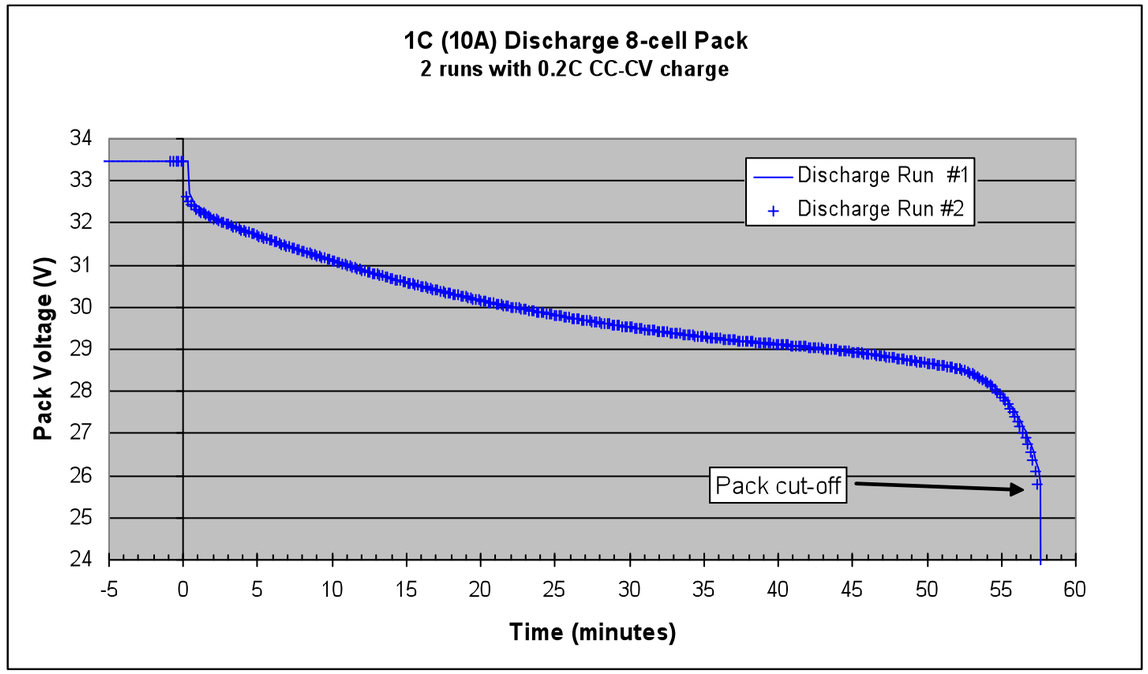


# Charging Data – 33.6V,10Ah Pack




- Charge Time for 10Ah SIL Lithium Ion Polymer Intelli-Pack
- 130 minutes total charge time at C/2 (5A) charge current
- Charge rate can be safely increased to 1C (10A)

# Discharge Data – 33.6V,10Ah Pack




- 1C Discharge Rate – 10A Load
- Flat Discharge Curve with ~ 57 minute run time
- Undervoltage protection cutoff at 2.7V / cell

# Environmental Qualification Levels

**Operating temp:** - 20C to +70C

**Storage temp:** - 55C to +85C

## Qualified to DOD Missile Environment Levels

**Thermal Humidity:** -20C to +60C (24 cycles, 1 hour dwells at each temperature extreme

**Thermal Vacuum:** 400,000 Ft. (2 x 10-7 PSIA)
-20C to +60C

**Random Vib.:** 26.4 grms, 3-Axis, 0-2000Hz

**Sine Vibration:** 14.14 Gpk, 0-300Hz and
21.21 Gpk, 301Hz to 2000Hz, 3 Axis

**Shock:** 40G, 11msec, 3-Axis, bi-directional, 12 Shocks

**Acceleration:** 30G, 3-Axis, bi-directional

**Outgassing: Space Shuttle, all NASA codes**

**EMIC:** MIL-STD 461D CE102, CS101, CS114, CS115, CS116, RE102, RE103

# Way Ahead

- SIL's Lithium Intelli-Pack™ battery is adaptable for use in any size/configuration where a highly reliable, energy dense, intelligent power source is required for Launch Vehicles, Missiles, Satellites, ISS, Balloons and UAVs
- SIL's Lithium Intelli-Pack Batteries provide voltage monitoring for use during preflight conditioning and for in flight telemetry downlink via multiple communication interfaces
- SIL's Lithium Intelli-Pack is a ***cost effective***, ***easily qualified,*** and ***safe*** alternative to current chemistries.
- SIL desires to work with the NASA and the DOD to utilize the Lithium Intelli-Pack battery technology to ***meet*** and ***exceed*** all existing and future aerospace battery requirements.

# SIL Contacts for more Info

## Please visit the SIL Booth
## to see the Lithium Intelli-Pack Battery


**Space Information Laboratories**

Edmund Burke, President

Jason Walsh, Director of R&D

Santa Maria, California

Phone: 805-925-9010, Ext. 1#

Cell: 805-720-2784

Fax: 805-925-9017

E-mail: edmund.burke@spaceinformationlabs.com

www.spaceinformationlabs.com